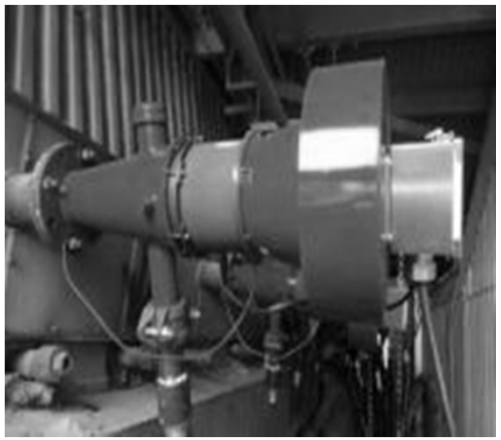
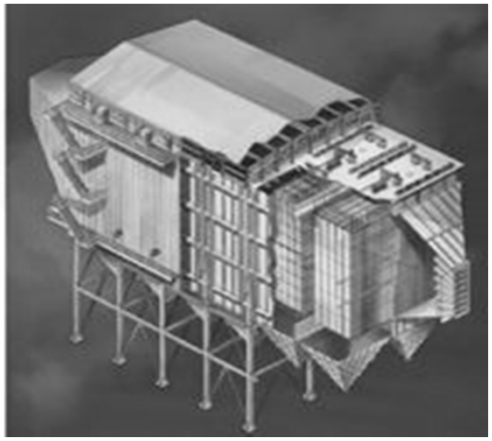
REINHOLD ENVIRONMENTAL Ltd.

2017 APC & Wastewater Round Table & Expo Presentation

July 17 & 18, 2017 in Charlotte, NC / Hosted by Duke Energy

Lance-less Injection of Flue Gas Sorbents





Presenter: Mitch Lund

Product Manager, Sorbent Injection

Location: 2017 APC and Wastewater Round Table

Date: July 17, 2017

Agenda

- The Problem
- A Solution
- Case Studies
- Summary

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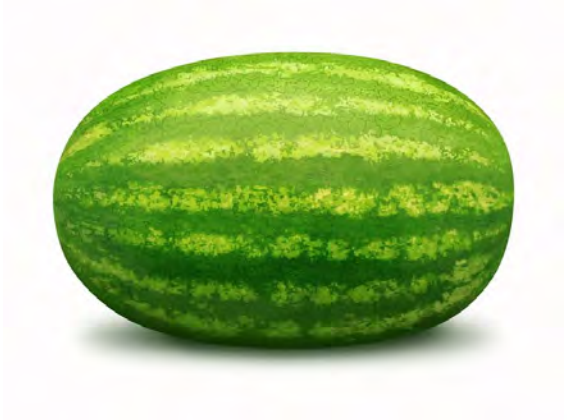
The Problem

- Injection lances are the traditional method used to inject dry sorbents
- Lances are simple BUT increase costs due to inefficient injection and high maintenance burden.

The Problem- Consider This

- Sorbent use inefficiency stems from the fact that the flue gas itself prevents large scale dispersion in a short period of time.
  - Drives up sorbent operating expenses
- Consider
  - Flue gas is on order of 1,000,000 ACFM
  - Flow out of lance is on order of 50 ACFM



Vs.

The Problem- Consider This

- It is well documented how important it is to control heat exposure in DSI systems (sodium and calcium sorbents).
  - Reduces risk of material scaling and lance plugging.
- Consider
  - Recommended conveying temperatures <140F
  - Post AH Flue Gas temperatures ~280-350F
  - Pre AH Flue Gas temperatures ~700F

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A Solution - Sorb-Tec™

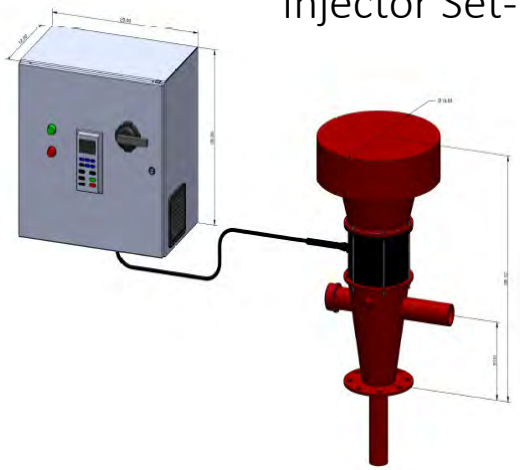
What is Sorb-Tec?

Sorb-Tec is a technological improvement to the “flue gas momentum” conundrum that exists in sorbent injection. It utilizes low pressure, high volume air to create enough velocity to overcome the flue gas momentum and create better sorbent dispersion, resulting in improved sorbent efficiency.

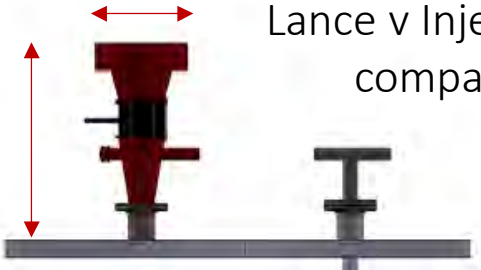
A Solution - Sorb-Tec™

- Like-for-like lance replacement
- Completely external to duct
- Ties into existing flange
- No modification to DSI / ACI system
- Streamlined & compact design
- Each injector has own fan(s)
- VFD for per injector flexibility

Injector Set-Up



Lance v Injector comparison



	Injector	Panel
Height	28”	20”
Width	16”	20”
Depth	16”	12”

A Solution - Sorb-Tec™ Specifications

- Design specifications standardized
- Longest operating injectors ~ 1 year
- Plug & play installation

Base Injector

Standardized Per Injector Specifications	
Power Supply	480 Volt @ ~7 amps/injector
Power Consumption	Average 6.5kW
Air Flow	Up to 2,000 CFM/injector
Pressure	Up to 10 INCW
Frequency	Up to 400 Hz
Weight	~50 lbs

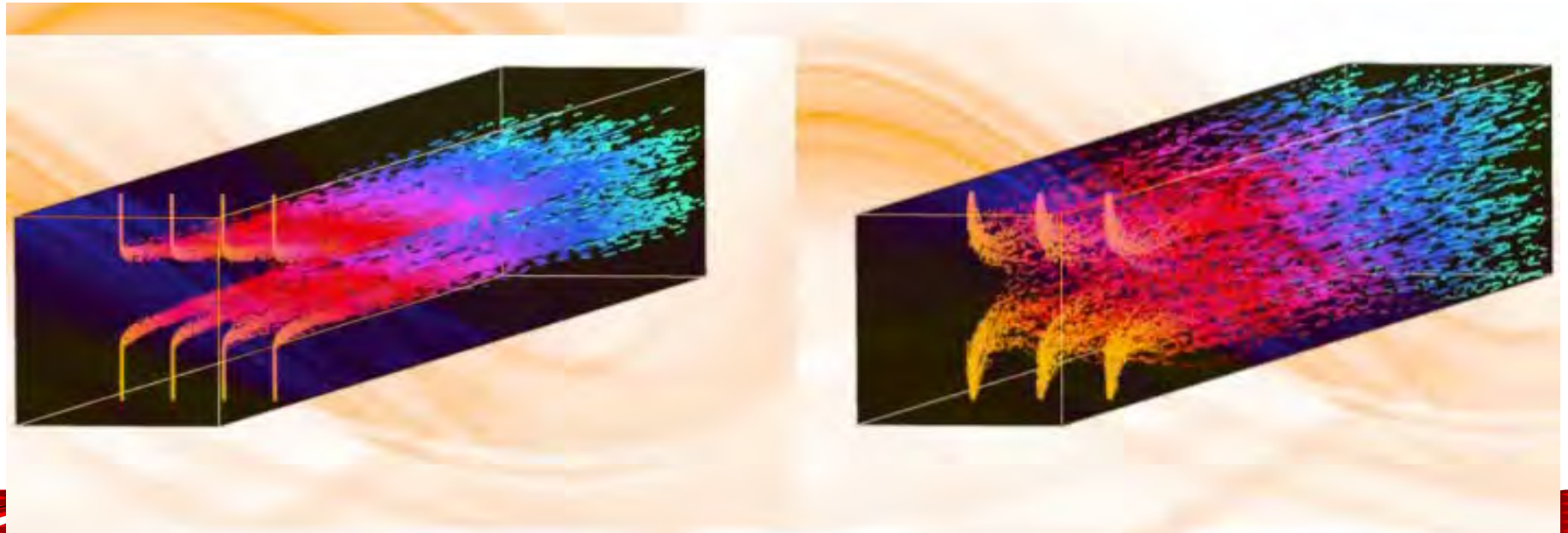
Injector w/ Sound Enclosure

A Solution- Consider This

- Solution: SORB-TEC
  - Creates momentum via velocity of boosted air.
  - Similar to NFL RB fighting through 11 defenders; he will be tackled eventually by momentum of defense, but gives a fighting chance of success.

A Solution- Sorb-Tec Visualized

Traditional Lance Injection	Sorb-Tec™ Technology
- Different lengths used to increase mixing	- Standardized injector fits to existing flange
- Long residence time required to disperse	- Boosted injection promotes wider dispersion
- Lances plug due to temperature & moisture	- No plugging with minimal maintenance
- High cost to operate and maintain	- Reduce sorbent usage by up to 40%



A Solution – Range of Benefits

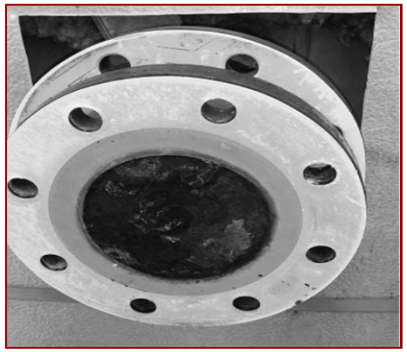
- Patented technology to enhance the dispersion and mixing of the sorbent within the duct, seamlessly installed for ease of installation and operation
- With fast payback, Sorb-Tec provides clients with a wide array of benefits

Cost Effective

Up to 80% sorbent savings against standard lances

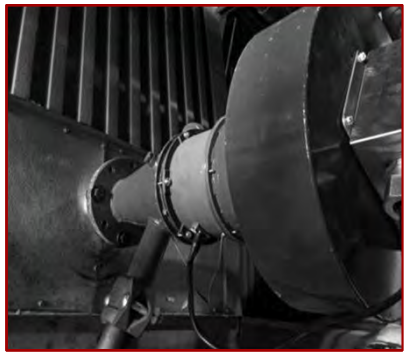
Future Proofing

Ability to further reduce emissions by up to 40%



Reduced Maintenance

Minimize lance-related pluggage via innovative design



Simple Retrofit

Ease of install and testing through ‘plug & play’ installation

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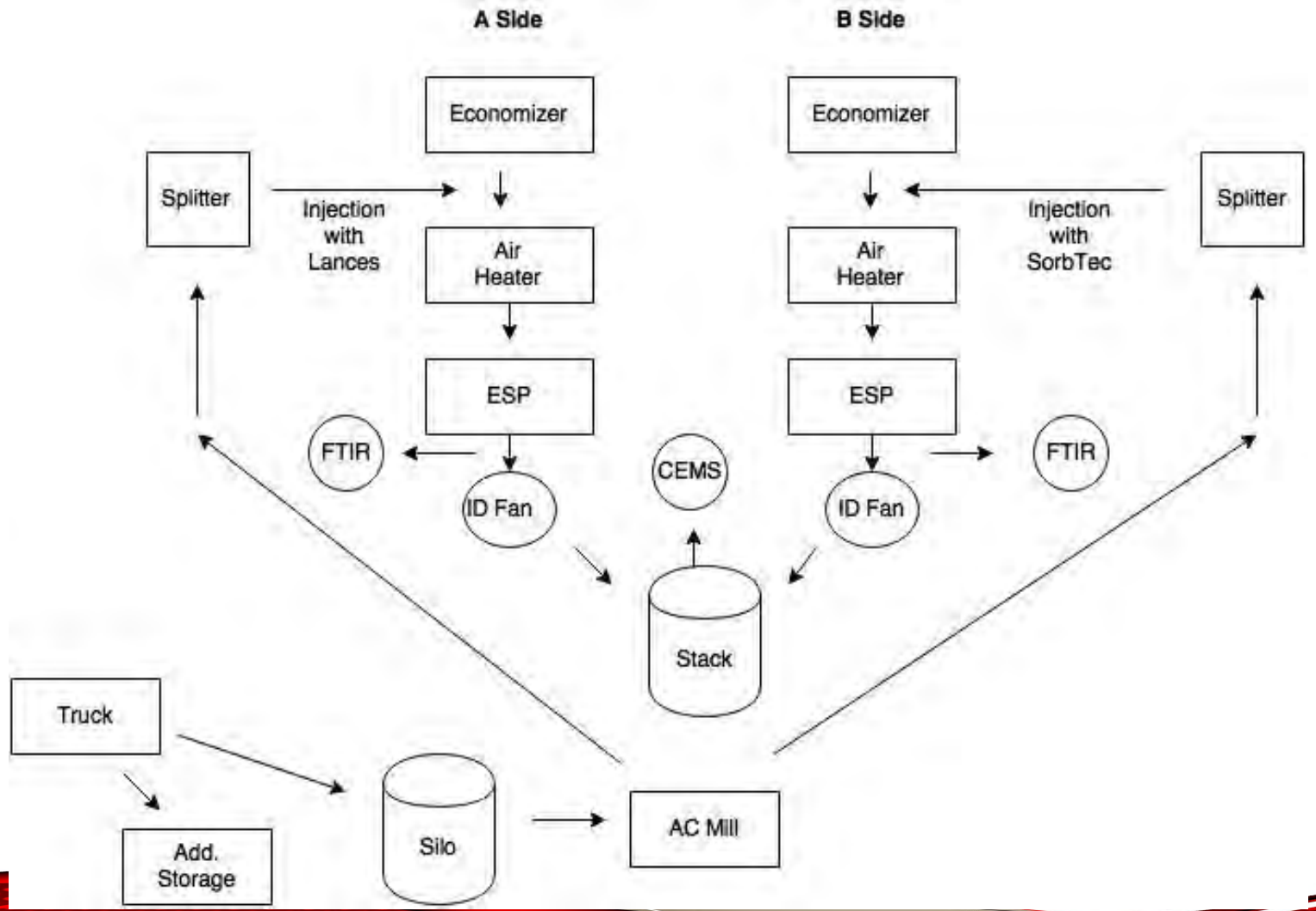
- Case Study 1
- Case Study 2
- Case Study 3

Study 1 | Newton Power Station

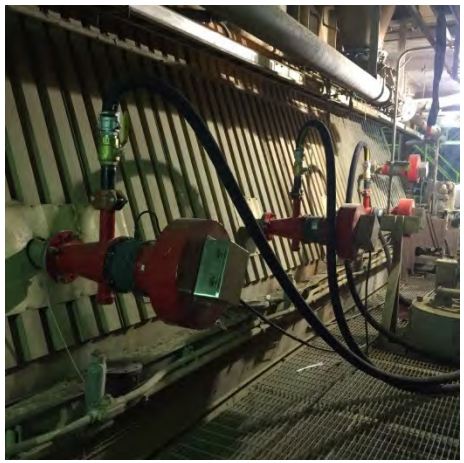
Primary Objectives

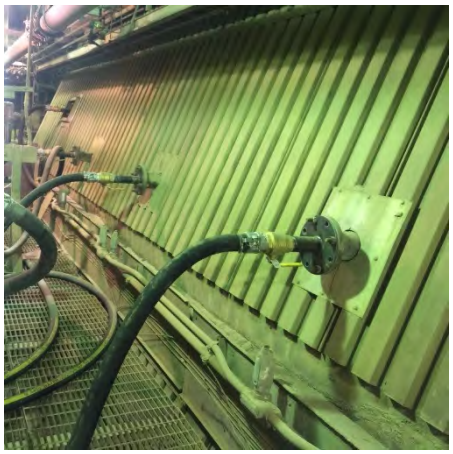
1. Meet stack SO_2 limit of 0.23 lb/MMBtu (~60% reduction)
2. Evaluate SBC sorbent savings with Sorb-Tec over lance based technology

Study 1 | Newton Power Station



Study 1 | Newton Power Station





AH Inlet Testing

1. Split duct (8 injectors on side B, 8 lances on side A).
2. EPA approved SO2 CEMS at stack.
3. Confirmed equal flows and SO2 concentrations on both ducts.
4. Injected individually to each duct.

Study 1 | Newton Power Station

Study 1 | Newton Power Station

Summary

1. Achieved ~16% reduction in sorbent use (at 70% removal- future design)
2. Estimated annual savings: $1,000,000
3. Improved SO2 Removal Performance by 10% (at same injection rate)

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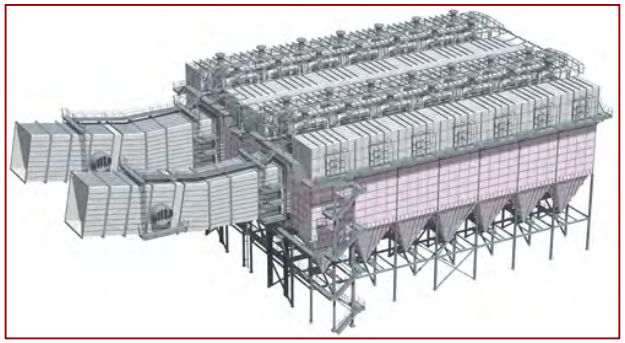
Study 2 | 330 MW Station, located S.East

Primary Objectives

1. DSI system using Hydrated Lime for SO_3 Control
2. Evaluate performance improvement over existing operating conditions
3. Evaluate maintenance requirements for lance-less technology (plugging)

Study 2 | 330 MW Station, located S.East

- Unit Layout
  - Air Heater
  - Dry ESP
  - H. Lime DSI
  - PAC Injection
  - Baghouse
  - Wet FGD
  - Stack



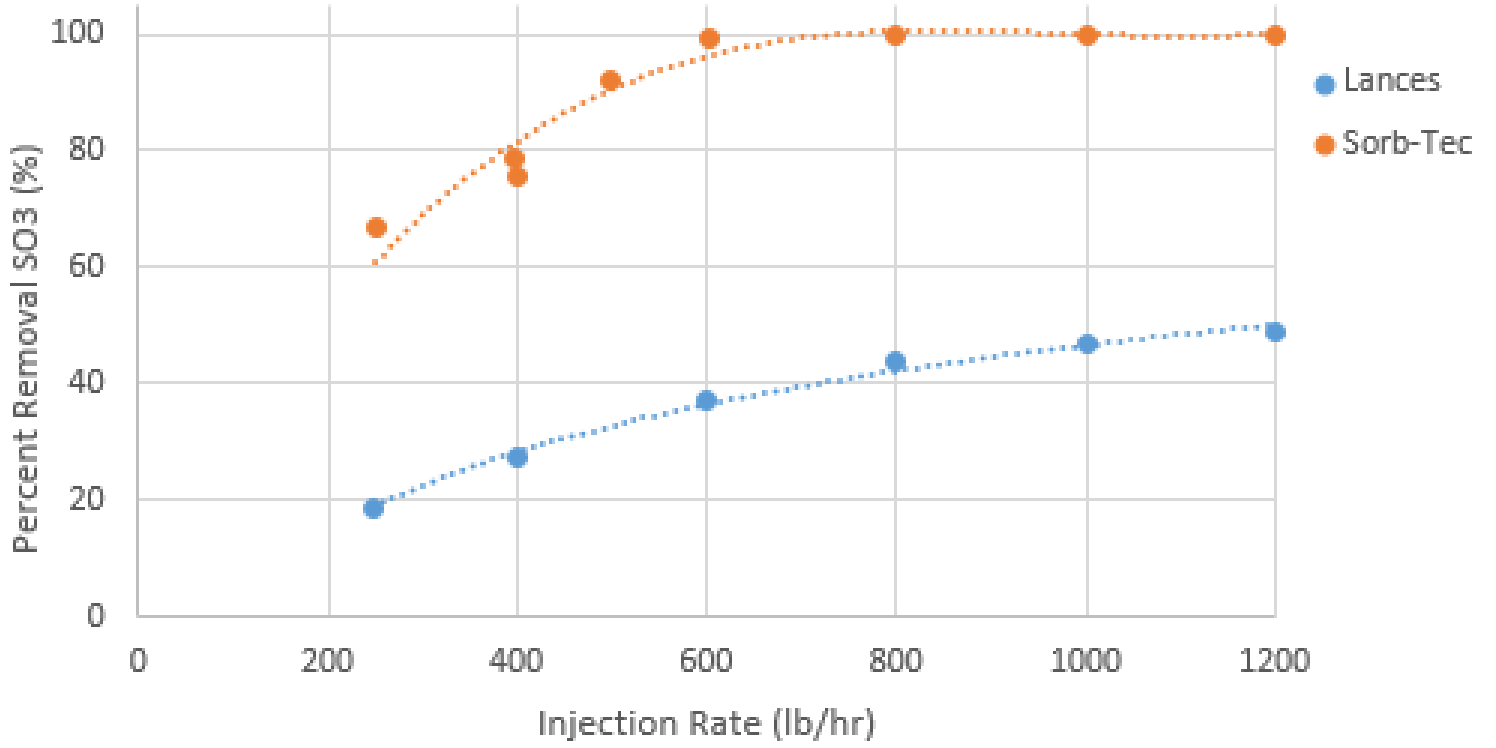
Study 2 | 330 MW Station, located S.East

Post ESP Testing

1. Single Duct Injection (8 total injectors).
2. Breen probe prior to baghouse.
3. Method 8A testing also performed.
4. Lance based data collected from historical results.

Study 2 | 330 MW Station, located S.East

Result | SO3 Removal (%) vs HL Injection Rate



Study 2 | 330 MW Station, located S.East

Summary

1. Achieved target performance with ~65% less sorbent.
2. Delivering estimated annual savings of $550,000 per system/annum
3. Achieved non-detectable SO_3 at typical injection rates
4. System reliability of 97.5% during the trial
5. In addition, preliminary results showed Sorb-Tec achieved 19% HCl removal whereas lances achieved 6% (200%+ performance increase)

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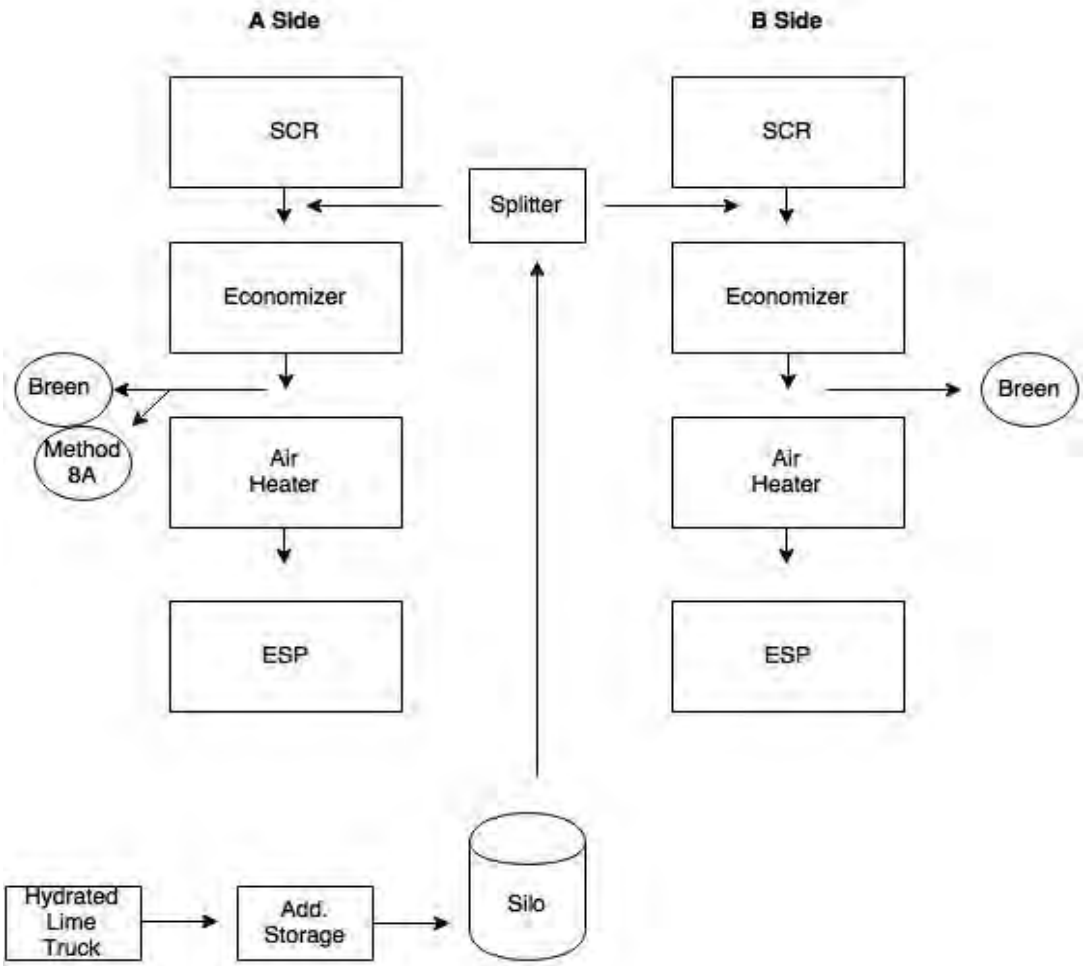
Study 3 | Cross Station

Primary Objectives

1. DSI system using Hydrated Lime for SO_3 Control & Blue Plume
2. Evaluate performance improvement over existing operating conditions
3. Evaluate Sorb-Tec over other technology alternatives (i.e. advanced lances)

Study 3 | Cross Station

- Unit Layout



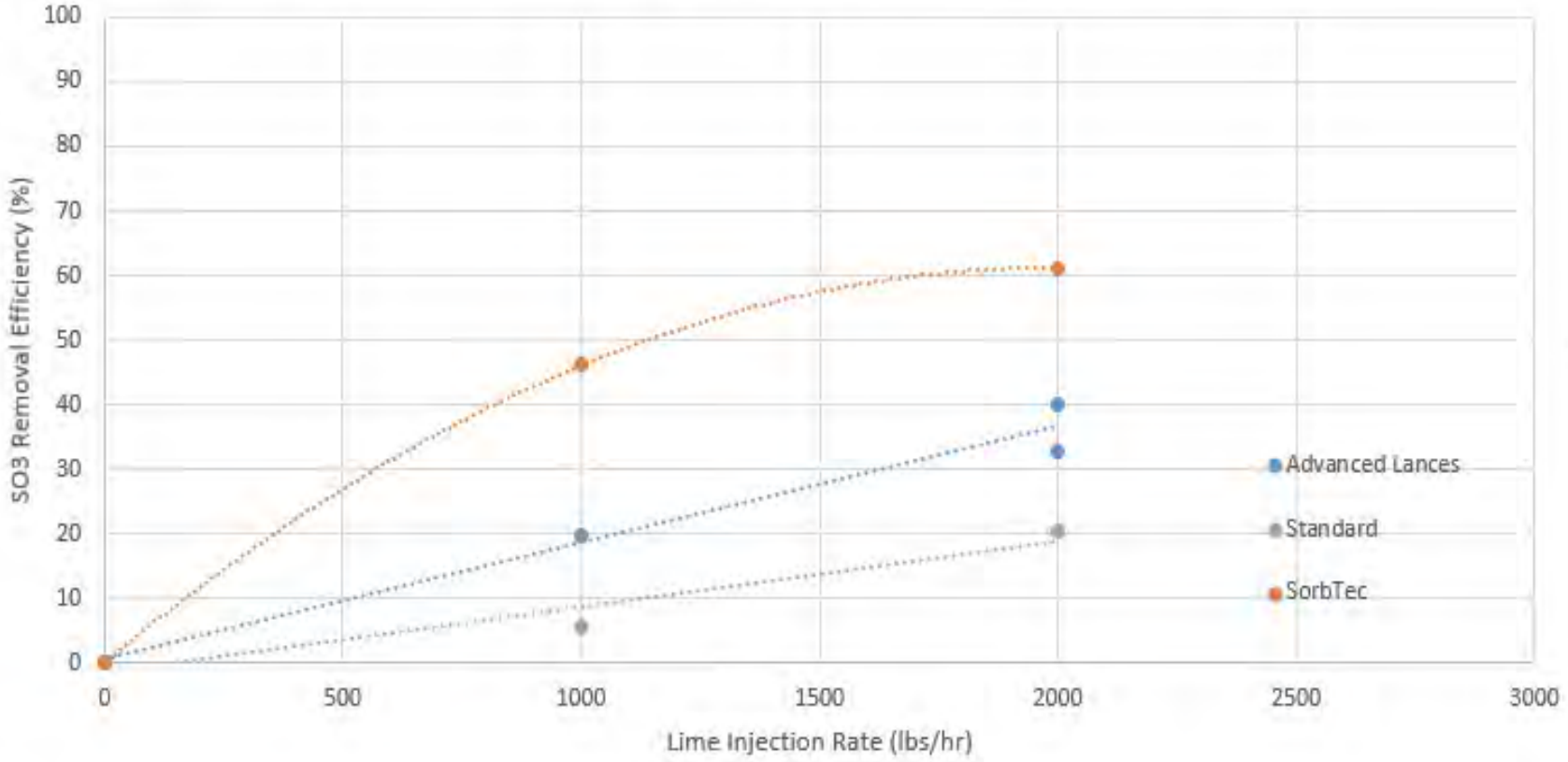
Study 3 | Cross Station

SCR Outlet Testing

1. Split duct (Duct A- 6 ports used, Duct B- 2 used ports)
2. Standard lance, advanced lance and Sorb-Tec tested.
3. EPA Method 8A performed on A side duct at APH inlet.
4. Breen probe installed prior to APH on both ducts.

Study 3 | Cross Station

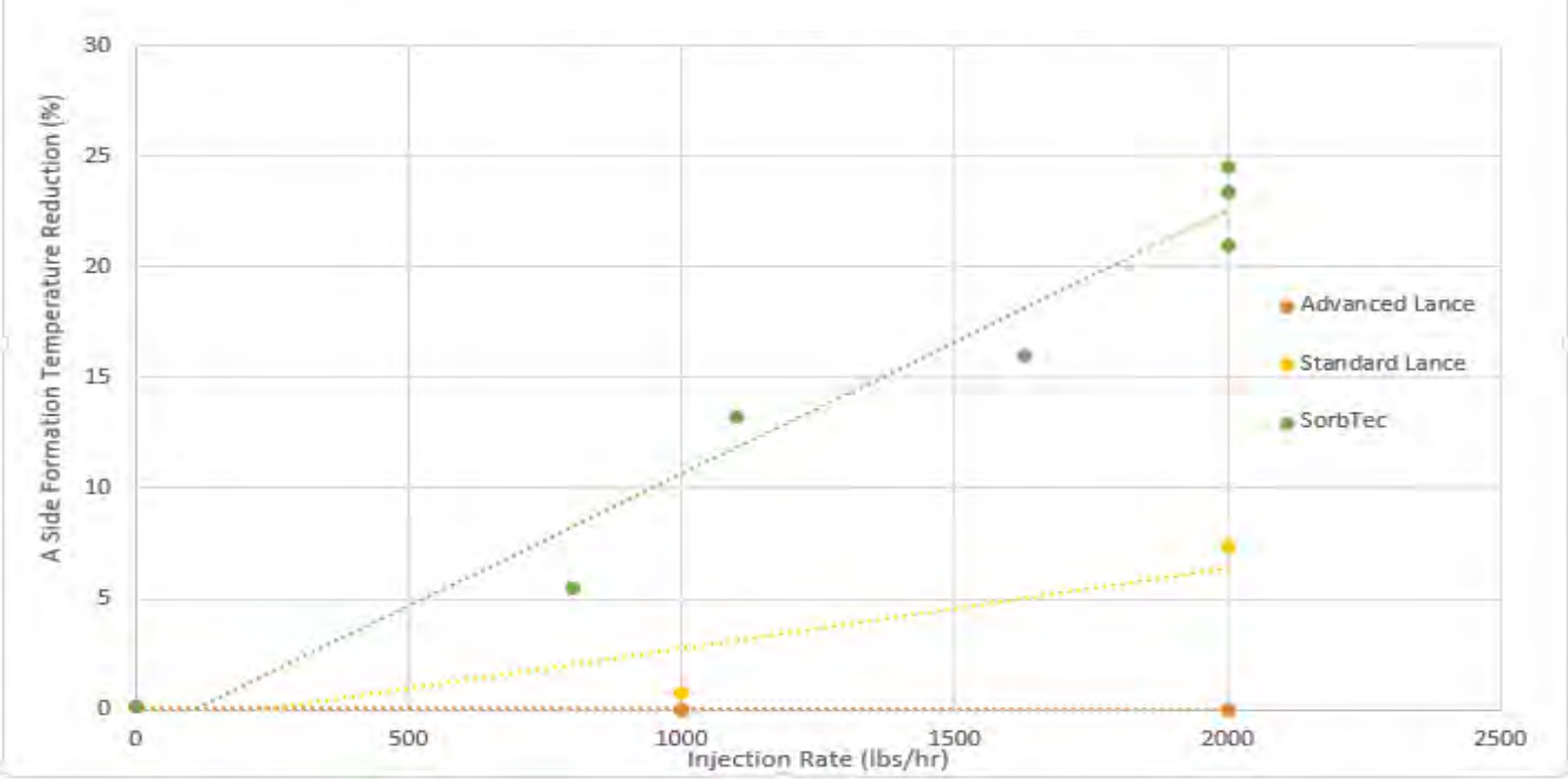
Result | APH Inlet SO_3 Removal vs HL Injection Rate *(Method 8A data)*



Data Recorded via Method 8A testing

Study 3 | Cross Station

Result | APH Inlet SO_3 Removal vs HL Injection Rate *(Breen data)*



Study 3 | Cross Station

- **Result** | Method 8A and Breen- what does it mean
  - Breen Data suggests Sorb-Tec > Standard Lance > Advanced Lances
  - 8A Data suggests Sorb-Tec > Advanced Lance > Standard Lance
- Advanced Lances and Sorb-Tec were in same ports; standard lances in off-center ports ~1 ft downstream
- Sorb-Tec margin over "next best technology" almost identical in both cases (~65% savings in both cases)
- **Possible hypothesis:** Sorb-Tec offers more prevalent mixing than lance technologies that resulted more from localized treatment.

Study 3 | Cross Station

Test Summary

1. Achieved ~60% reduction in sorbent (at existing performance)
2. Delivering estimated annual savings of $400,000 per system/annum
3. Improved existing performance by 50% (8A) or 200% (Breen Probe)
4. System reliability of 100% during the trial

Study 3 | Cross Station

Balance of Plant Effects

Technology	Load	Inj. Points (A Duct)	Injection Rate	Added CFM	A Side Duct Econ O2 (%)	A Side Fan Amps	A Side Flue Gas Temp
Standard Lance	640	6	2000	300	2.8	628	574
Advanced Lance	640	6	2000	300	3.2	634	582
Lanceless	640	6	2000	12,000	2.6	633	580

- Bulk flue gas properties >> ambient air properties from Sorb-Tec
- Added additional CFM does not appear to effect BOP.
  - No change in O2 content, ID fan performance and flue gas temp.

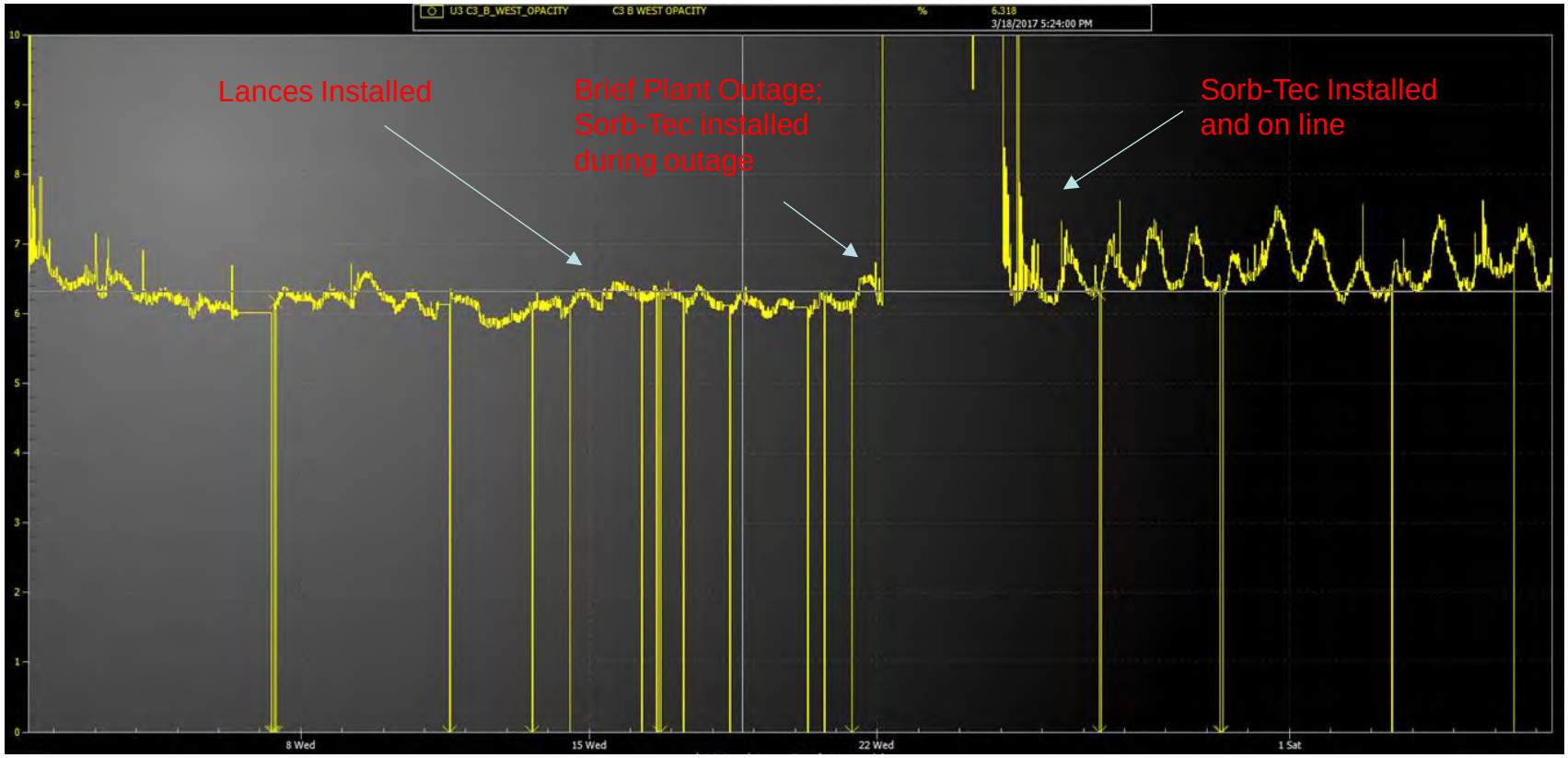
Study 3 | Cross Station

Spring 2017 Update

1. Customer no longer needs trim location (post ESP, pre scrubber).
2. Has been utilizing Sorb-Tec on Unit 3 since March 2017.
3. Interesting results on ESP performance with Sorb-Tec….

Study 3 | Cross Station

Spring 2017 Update



Study 3 | Cross Station

Spring 2017 Update

1. Additional SO3 removal had an impact on ESP performance- no additional conductivity from sulfuric acid mist condensation.

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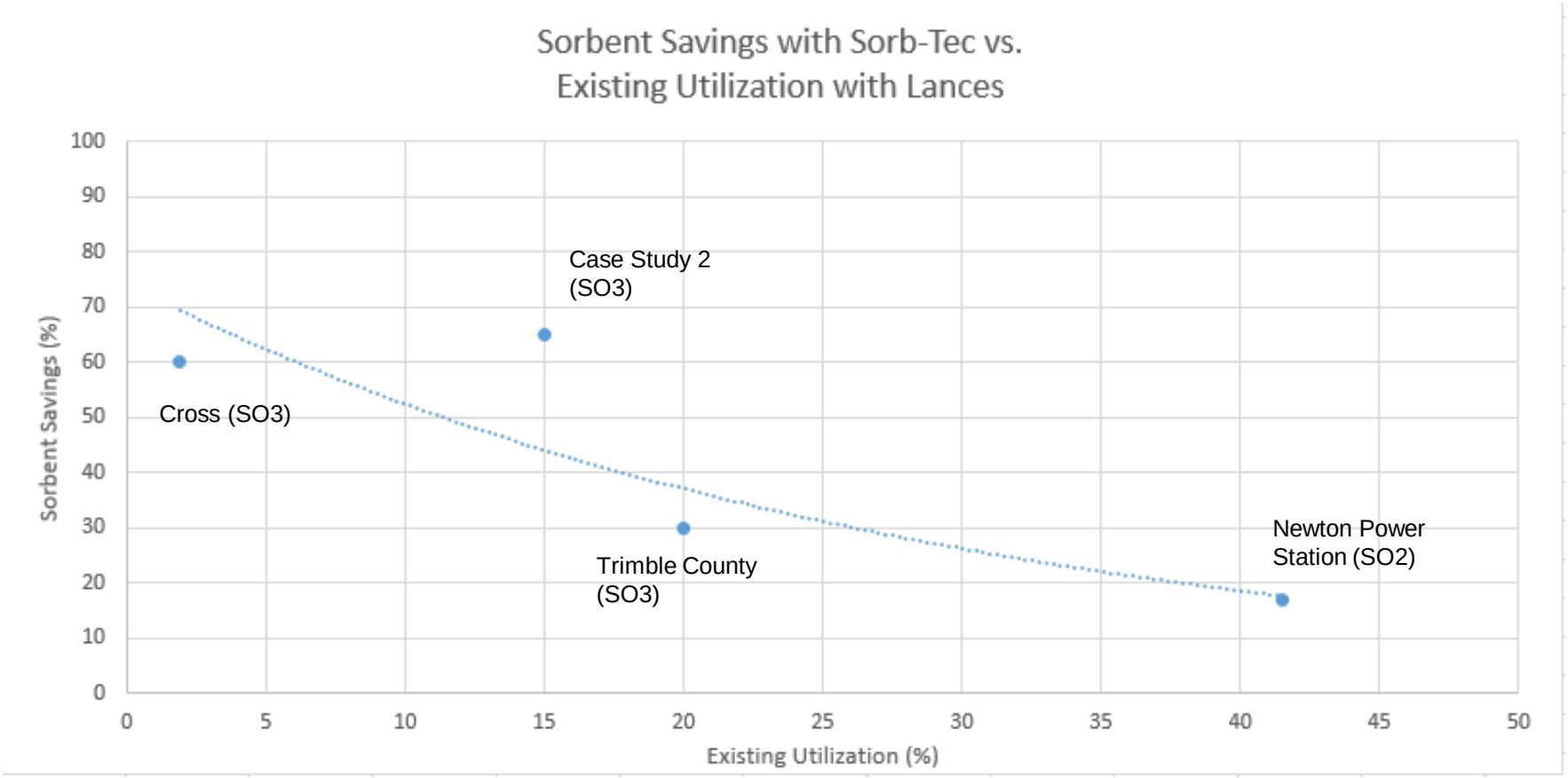
Sorb-Tec™ | Summary

What Dictates System Improvement Potential?

Sorbent Utilization – Amount of Sorbent being injected vs. amount of sorbent actual being used in mitigation

1. It is easier for sorbent to “find” pollutant if there are more of them.
    1. SO2 >> HCl ~SO3 >> Hg
2. Sorbent dispersion benefits should be higher in magnitude in lower sorbent utilization scenarios.

Sorb-Tec™ | Summary



Sorb-Tec™ | Summary

- Sorb-Tec is now a proven technology
  - Evidenced significant cost savings with long term operational data in place (multiple demonstrations lasting 1+ year).
- On-site testing available to evidence performance
  - Minimally invasive fast retrofit
  - Very easy to quantify benefit to technology
- Fast ROI, often <2 year payback

Sorb-Tec™ | Questions?